REMARKS

I. Introduction

In response to the Office Action dated April 15, 2004, no claims have been canceled, amended or added. Claims 1-57 remain in the application. Entry of these remarks, and re-consideration of the application, is requested.

II. Prior Art Rejections

A. The Office Action Rejections

In paragraphs (3)-(4) of the Office Action, claims 1, 18-20, 22-26, 30, 31, 33-39, 41-45, 49, 50, and 52-57 were rejected under 35 U.S.C. §103(a) as being unpatentable over Sowar, U.S. Patent No. 5,351,196 (Sowar). In paragraph (5) of the Office Action, claims 2-17, 21, 27-29, 32, 40, 46-48, and 51 were rejected under 35 U.S.C. §103(a) as being unpatentable over Sowar in view of Ji et al., "Machine Interpretation of CAD Data for Manufacturing Applications," ACM published September 1997, pages 264-311 (Ji).

Applicant's attorney respectfully traverses these rejections.

B. The Applicant's Independent Claims

Independent claims 1, 20 and 39 are generally directed to terminating profile sweeps for multiple bodies in a computer-implemented solid modeling system. Claim 1 is representative, and comprises the steps of:

(a) generating a planar profile of one or more curves;

(b) sweeping the profile along a specified path to generate a tool body; and

(c) terminating the swept profile when the tool body interacts with a plurality of blank bodies to a predefined extent.

C. The Sowar Reference

Sowar describes an invention relating to processes for the automatic generation of numerical control (NC) tool paths in a CAD/CAM environment. The present invention operates on mechanical parts described as solid models. The process employs well-defined solid models of the part to be machined and the raw stock from which it will be machined. The volumetric difference between the stock and the part defines the material (delta volumes) that must be cut away during the actual machining process. Delta volumes are solid models, and users (or an expert system) can

subdivide delta volumes into smaller volumes that are consistent with a manufacturing process plan. A delta volume and a user-defined strategy for machining the delta volume are then input to NC algorithms. The algorithms generate NC tool paths that remove as much delta volume material as possible. Tool volumes are automatically generated from NC tool paths to represent the volume traversed by the cutting tool. By subtracting the tool volume from the delta volume, the material that remains to be machined modeled and stored as new delta volumes. The subtraction of the tool volume from the stock defines a new stock model that represents the incremental change in stock when the NC tool path is processed at the machine tool. The process is repeated until all delta volumes have been machined and the part has been manufactured.

D. The Ji Reference

Ji describes machine interpretation of CAD data for manufacturing applications. Machine interpretation of the shape of a component for CAD databases is an important problem in CAD/CAM, computer vision, and intelligent manufacturing. It can be used in CAD/CAM for evaluation of designs, in computer vision for machine recognition and machine inspection of objects, and in intelligent manufacturing for automating and integrating the link between design and manufacturing. This topic has been an active area of research since the late '70s, and a significant number of computational methods have been proposed to identify portions of the geometry of a part having engineering significance (here called "features"). However, each proposed mechanism has been able to solve the problem only for components within a restricted geometric domain (such as polyhedral components), or only for components whose features interact with each other in a restricted manner. The purposes of this article are to review and summarize the development of research on machine recognition of features from CAD data, to discuss the advantages and potential problems of each approach, and to point out some of the promising directions future investigations may take. Since most work in this field has focused on machining features, the article primarily covers those features associated with the manufacturing domain. In order to better understand the state of the art, methods of automated feature recognition are divided into the following categories of methods based on their approach: graph-based, syntactic pattern recognition, rule-based, and volumetric. Within each category we have studied issues such as the definition of features, mechanisms developed for recognition of features, the application scope, and the assumptions made. In addition, the problem is addressed from the perspective of information input requirements and the advantages and disadvantages of boundary representation, constructive solid geometry

(CSG), and 2D drawings with respect to machine recognition of features are examined. Emphasis is placed on the mechanisms for attacking problems associated with interacting features.

D. <u>The Applicant's Independent Claims Are Patentable Over the References</u>

The Applicant's invention, as recited in independent claims 1, 20 and 39 is patentable over the references, because it contains limitations not taught by the references.

As noted in Applicant's specification, terminating profile sweeps is a fundamental operation in solid-modeling systems. Applicant's invention describes a new technique for handling the termination of a profile sweep when multiple blank bodies are involved. Specifically, nothing in the references teach or suggest terminating a swept profile that generates a tool body, when the tool body interacts with a plurality of blank bodies to a predefined extent.

On the other hand, the Office Action states the following:

> 4. Claims 1,18-20, 22-26, 30, 31, 33-39, 41-45, 49, 50 and 52-57 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sowar (5,351,196).
>
> Claim 1, Sowar et al. discloses generating a planar profile of curves (generating a slicing plane which is intersected with the solid modeling faces to determine the curves representing regions that the tool may enter; col. 3, lines 24-26 or organizing the curve into profiles, col. 13, lines 9-10); sweeping the profile (constraint curve profile) along a specified path (tool path) to generate a tool body (tool volume; col. 14, lines 9-12), terminating the swept profile when the tool body interacts with blank bodies to a predefined extent (if all delta volumes have been removed, the process terminates, col. 14, lines 36-37); Sowar does not teach predefined extent; however, Sowar discloses "z extents are needed to determine start and stop positions for slicing and control", col. 11, lines 23-27. These features considered corresponding to the step of terminating the swept profile when the tool body interacts with a plurality of blank bodies to a predefined extent which disclosed by the claim invention, because Sowar teaches that "this is done by projecting the constraint profile through the z extent of the delta volume" (col. 11, lines 44-60); z extent for a delta volume are maintained and supplied by the underlying solid modeling system (col. 11, lines 19-27). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize the Sowar' s teaching for using z-extent to stop or terminate the constraint profile by standard interactive techniques, because it would provide a method for automatically generating finishing tool paths for all or portions of delta volumes in a CAD/CAM environment (col. 6, lines 40-42).
>
> Claim 18, Sowar et al. discloses the tool body interacts (intersects) with the blank bodies according to Boolean selected from a group comprising a joining (union) of the tool body (tool volume) with blank bodies (delta volume), a cutting operation (cutting tool to subtract or remove) of the tool body from the blank bodies (col. 2, lines 60-66).

Claim 19, Sowar et al. discloses the tool body is generated by sweeping the profile (tool volume, col. 14, lines 6-12), the tool body extends to a predefined length (z-extend from minimum to maximum z-coordinates values, col. 11, lines 19-27); the tool body extends through the blank body, but no further (from maximum to minimum z); the tool body extents to a first face on the blank body, wherein the first face cuts the tool body; the tool body extends up to, but does not penetrate, a selected face (constraint volumes intersected with the delta volume define the volume which the stool must stay within; see col. 11, line 44 through col. 12, line 7); the tool body is swept between two selected faces (col. 14, lines 9-12).

Claims 20 and 39, the rationale provide in the rejection of claim 1 is incorporated herein.

Claims 22-26, 30, 31, 33-38, 41-45, 49, 50 and 52-57, the rationale provided in the rejection of claims 3-7,11,12 and 14-19 is incorporated herein.

5. Claims 2-17, 21, 27-29, 32, 40, 46-48 and 51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sowar (5,351,196) in view of Ji et al. "Machine Interpretation of CAD Data for Manufacturing Applications", ACM published September 1997, pages 264-311.

Claim 2, Sowar et al. does not teach blank graphs; however, Ji et al. discloses creating a cellular topology graph of the tools (pockets, slots, holes, steps, fig. 1) and blank bodies (raw stock bounded volume; see section 2.1, pages 270-273; fig. 4); extracting tool and blank graphs (parts) from the cellular topology graph (see section 4.1.2, the left column of page 278); performing a post-processing phase to integrate results from the extracted tool and blank graphs (parameter extraction obtains the position, orientation and dimensions of the features. Adjacent features may be combined to form compound features for a hierarchy of features, see the left column of page 286). It would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize a cellular topography graph of the tools and apply a method of parameter extraction taught by the Ji's teaching into the tool paths of the Sowar' s system for building a topography graph of the tools and blank bodies, because the advantage of a hierarchical description (topography graph) of the extracted features is that it provides a more global view of the part which can be used in CAD/CAM evaluation of designs (see the bottom on the left column of page 277). Further, claims 8-10 and 13, Ji et al. also teaches the pre-processing performs cellular decomposition on the tool body and blank body to create the cellular topology graph (cell decomposition, see the left column of page 271); adding termination vertices to the tool graph (The concepts of adding and subtracting elementary volumes, see the right column of page 271 to page 272, fig. 4d); deriving bundle graphs from the tool graph that to determine the potential "from" and "to" termination ("through step", "through slot", see fig. la, page 267; fig. 7, page 279); a graph whose vertices represent cells used to create an output body (fig. 4d).

Claims 3-7, Sowar et al. discloses the pre-processing labels (or marks) faces and edges of the tool (part model; col. 8, lines 25-29) and blank bodies (stock model; col. 9, lines 13-14); tracking which faces came from which body (col. 9, lines 28-29); propagate edge attributes for each face (manufacturing attributes can range from simple to complex to the face, see col. 8, lines 30-35); the faces and edges are labeled with attributes (col. 3, lines 15-18); construct a blank body (well-defined the raw stock models, col. 4, lines 16-19).

Claims 11 and 12, Sowar et al. teaches the analysis performs label propagation (attributes can range from simple to complex) in which marking of faces as a from-face or to-face adjacent to faces originally marked as from-faces and to-faces (one or more cutting tools, selection of the machining operation through each machining stage, see col. 8, lines 30-50); handling a specific termination type relative to the bodies (delta volumes, col. 14, lines 36-41).

Claims 14-17, Sowar et al. discloses results from the analysis according to the Boolean operation (col. 3, lines 42-53); a truncated tool body (the stock model that will be cut or remove on the machine tool) computed as union of cells of the tool body (solid models stock model, delta volumes, machining setup models, col. 4, lines 17-24); a truncated (subtracted) tool body computed from the Boolean of the tool body (part model) with a blank body (stock model), a target body (delta volume) (col. 4, lines 34-36; col. 9, lines 17-27).

Claims 21, 27-29, 32, 40, 46-48 and 51, the rationale provided in the rejection of claims 2, 8-10 and 13 is incorporated herein.

Response to Arguments

6. Applicant's arguments filed 11/26/03 have been fully considered but they are not persuasive.

With respect to applicant's arguments, Sowar's reference shows the limitations of independent claims 1, 20 and 39 as explained in the Office Action. Claim 1, Sowar et al. discloses generating a planar profile of curves (generating a slicing plane which is intersected with the solid modeling faces to determine the curves representing regions that the tool may enter; col. 3, lines 24-26 or organizing the curve into profiles, col. 13, lines 9-10; figs. 11A and 11B); sweeping the profile along a specified path (tool path) to generate a tool body (a tool volume is an exact solid model that represents the total volume of space swept out by cutting tool during complete traversal of the NC tool path; col. 14, lines 9-12); terminating the swept profile when the tool body interacts with blank bodies to a predefined extent (if all delta volumes have been removed (blank bodies), the process terminates, col. 14, lines 36-37); this is done by projecting the constraint profile through the z extent of the delta volume (col. 11, lines 44-60), the z-extents are needed to determine start and stop positions for slicing and control (col. 11, lines 23-27). These features considered corresponding to the step of terminating the swept profile when the tool body interacts with a plurality of blank bodies to a predefined extent which disclosed by the claimed invention, because z extent for a delta volume are predetermined, maintained and supplied by the underlying solid modeling system (col. 11, lines 25-27). For these reasons, the rejection of claims 1-57 are maintained.

Applicant's attorney respectfully disagrees with these rejections.

For example, with regard to the limitation "generating a planar profile of one or more curves," consider the description found in Sowar at the indicated locations:

Col. 3, lines 24-26 (actually lines 14-27)

The solid models are classified using attributes such as stock, part, and delta volume. Attributes may also be added to faces, holes, edges, vertices and features. The solid models and the attributes attached to the models, faces, features, etc. are used to determine successive depths of cut for the machining process. The user inputs a machining setup and a machining strategy. The system automatically determines the best depths of cut from the solid models and the machining strategy. Each depth of cut is used to generate a slicing plane which is intersected with the solid modeling faces to determine the curves representing regions that the tool may enter. The solid model and the attached attributes are thus used to prevent the tool from gouging the part.

Col. 13, lines 9-10 (actually lines 7-24)

Substep 10-12. Organize the Curves into Profiles. All the necessary curves have been determined, and the task becomes one of organizing the curves into profiles. The algorithm is similar to a 2-D Boolean operation. First, all the curves calculated in substeps 10-8 to 10-11 are intersected to obtain and store their intersection points (block 13-20a). Intersection points represent the places where a curve goes from a valid to an invalid region. For example, if the curves calculated in substeps 10-8 to 10-11 are in the form of two intersecting pairs of parallel lines enclosing a valid region which is square, then the process must find the intersection points at the four corners of the square. Each curve would then be divided into three segments. The segments outside the intersection points are discarded, leaving just the four curve segments defining the boundaries of the square. Thus the decisions as to which curve segments should be discarded are made at the intersection points.

Figs. 11A and 11B

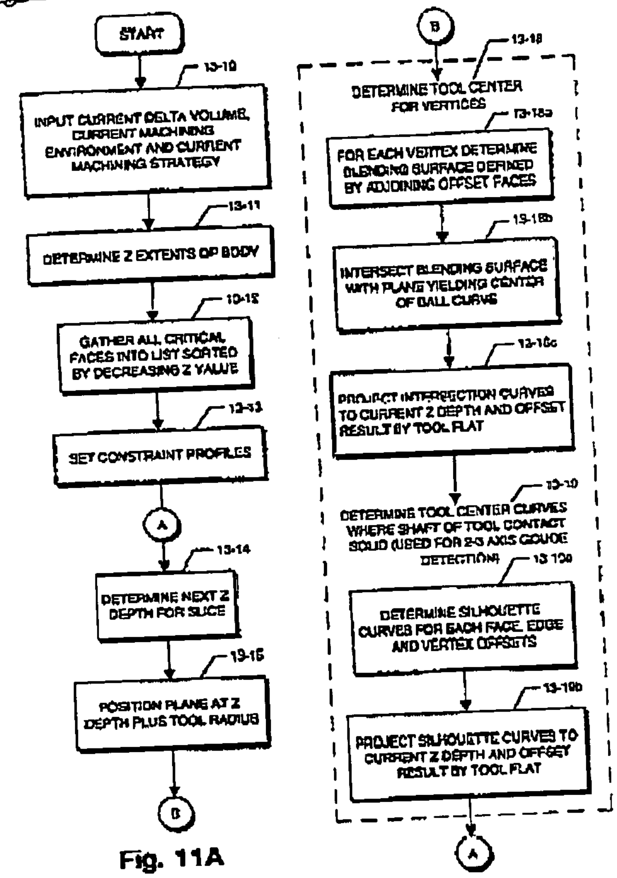

Fig. 11A

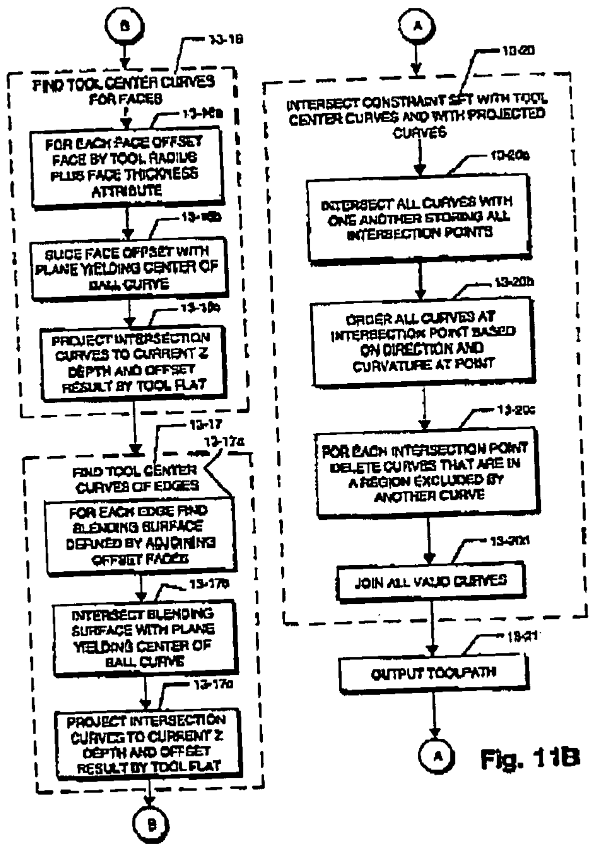

Fig. 11B

The above descriptions in Sowar do not teach or suggest generating a planar profile from one or more curves, wherein that planar profile is used to generate a tool body. Instead, the curves described above in Sowar refer to tool center curves, i.e., the necessary offsets from the faces, edges or vertices of the delta volume to prevent the cutting tool from intersecting with the part, wherein the delta volume is the space swept out by the cutting tool from the stock.

In another example, with regard to the limitation "sweeping the profile along a specified path to generate a tool body," wherein the profile is a planar profile generated from one or more curves, consider the description found in Sowar at the indicated location:

> <u>Col. 14, lines 9-12 (actually lines 6-12)</u>
> STEP 11. CREATING THE TOOL VOLUME. The next process step, as shown in FIG. 9, is to create a tool volume (14-1) from the NC tool path stored in block 26. A tool volume (23-3) is an exact solid model that represents the total volume of space swept out by the cutting tool during complete traversal of the NC tool path.

The above description in Sowar does not teach or suggest sweeping the profile along a specified path to generate a tool body, wherein the profile is a planar profile generated from one or more curves. In Applicant's specification, a Boolean operation between two or more bodies creates a new solid from portions of each body, wherein the bodies being modified being the "blank bodies," and the body performing the modification is the "tool body." More specifically, the tool body interacts with the blank bodies to create the part, which thereafter may be machined or otherwise manufactured. The operations in Sowar occur after such a part is defined, when the part is machined from stock. Consequently, this limitation in Applicant's claim differs from the tool volume described in Sowar, which comprises a solid model that represents the total volume of space swept out by the cutting tool during complete traversal of an NC tool path during the machining of the part from the stock.

In another example, with regard to the limitation "terminating the swept profile when the tool body interacts with a plurality of blank bodies to a predefined extent," consider the descriptions found in Sowar at the indicated locations:

> <u>Col. 14, lines 36-37 (actually lines 36-45)</u>
> STEP 13. END? If all delta volumes have been removed (15), the process terminates. If more delta volumes remain to be machined, the process is repeated starting with STEP 7, i.e., block 11 of FIG. 9. The process may also be ended with some delta volume left unremoved, for example because the user may have chosen to do so or because that unremoved delta volume cannot be machined. The decision to leave some delta volume unremoved is made in the process plan (step 2 above).

> <u>Col. 11, lines 44-60 (actually lines 36-45)</u>
> Substep 10-4. Specify 2-D Constraint Profiles. The user can optionally specify one or more 2-D constraint profiles (block 13-13) to further control where the cutting tool can and cannot go. A constraint profile is used internally in the algorithm to generate a volume. This is done by projecting the constraint profile through the Z-extent of the delta volume (determined in substep 10-2). Constraint volumes intersected with the delta volume define the volume which the tool must stay within. In this embodiment of the algorithm, constraint profiles are identified by the user using standard interactive techniques.
>
> Substep 10-5. Iterate to Remove Entire Delta Volume. The following substeps 10-6 to 10-13 are repeated until the entire delta volume has been processed, i.e., until the CURRENT.sub.-- DEPTH is below the minimum Z coordinate determined in substep 10-2.

Col. 11, lines 23-27 (actually lines 19-27)

Substep 10-2. Determine Maximum and Minimum Z-coordinates. The maximum and minimum Z coordinate values (Z-axis aligned with tool axis direction) for the current delta volume are then determined (block 13-11). These Z extents are needed to determine start and stop positions for slicing and control (blocks 13-14 through 13-21 in FIG. 11). Z extents for a delta volume are maintained and supplied by the underlying solid modeling system.

The above descriptions in Sowar do not teach or suggest terminating the swept profile when the tool body interacts with a plurality of blank bodies to a predefined extent. Again, the operations in Sowar occur after a part is defined, when the part is machined from stock, whereas this limitation of Applicant's invention refers to the interaction between the tool body and the blank bodies to create the part. Instead, the delta volumes described above in Sowar refer to the material being removed from the stock by machining to create the part, the constraint profiles described above in Sowar control where the cutting tool can and cannot go, because they are projected through the Z-extent of the delta volume, and the maximum and minimum Z coordinate values described above in Sowar determine start and stop positions for slicing and control in the delta volume. Moreover, Sowar refers to only a single blank body, not a plurality of blank bodies.

Because of these differences, it is respectfully asserted that Sowar does not anticipate or render obvious Applicant's invention. Moreover, the various elements of Applicant's claimed invention together provide operational advantages over Sowar. In addition, Applicant's invention solves problems not recognized by Sowar.

The Ji reference does not overcome the deficiencies of the Sowar reference. Recall that Ji was cited only against dependent claims 2, 8-10, 13, 21, 27-29, 32, 40, 46-48 and 51. Moreover, Ji does not describe Applicant's invention for handling the termination of a profile sweep when multiple blank bodies are involved.

Thus, Applicant's attorney submits that independent claims 1, 20 and 39 are allowable over the references.

Dependent claims 2-10, 22-30, and 32-40 are also submitted to be allowable over the references in the same manner, because they are dependent on independent claims 1, 20 and 39, respectively, and thus contain all the limitations of the independent claims. In addition, dependent claims 2-10, 22-30, and 32-40 recite additional novel elements not shown by the references.

III. Conclusion

In view of the above, it is submitted that this application is now in good order for allowance and such allowance is respectfully solicited. Should the Examiner believe minor matters still remain that can be resolved in a telephone interview, the Examiner is urged to call Applicant's undersigned attorney.

Respectfully submitted,

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